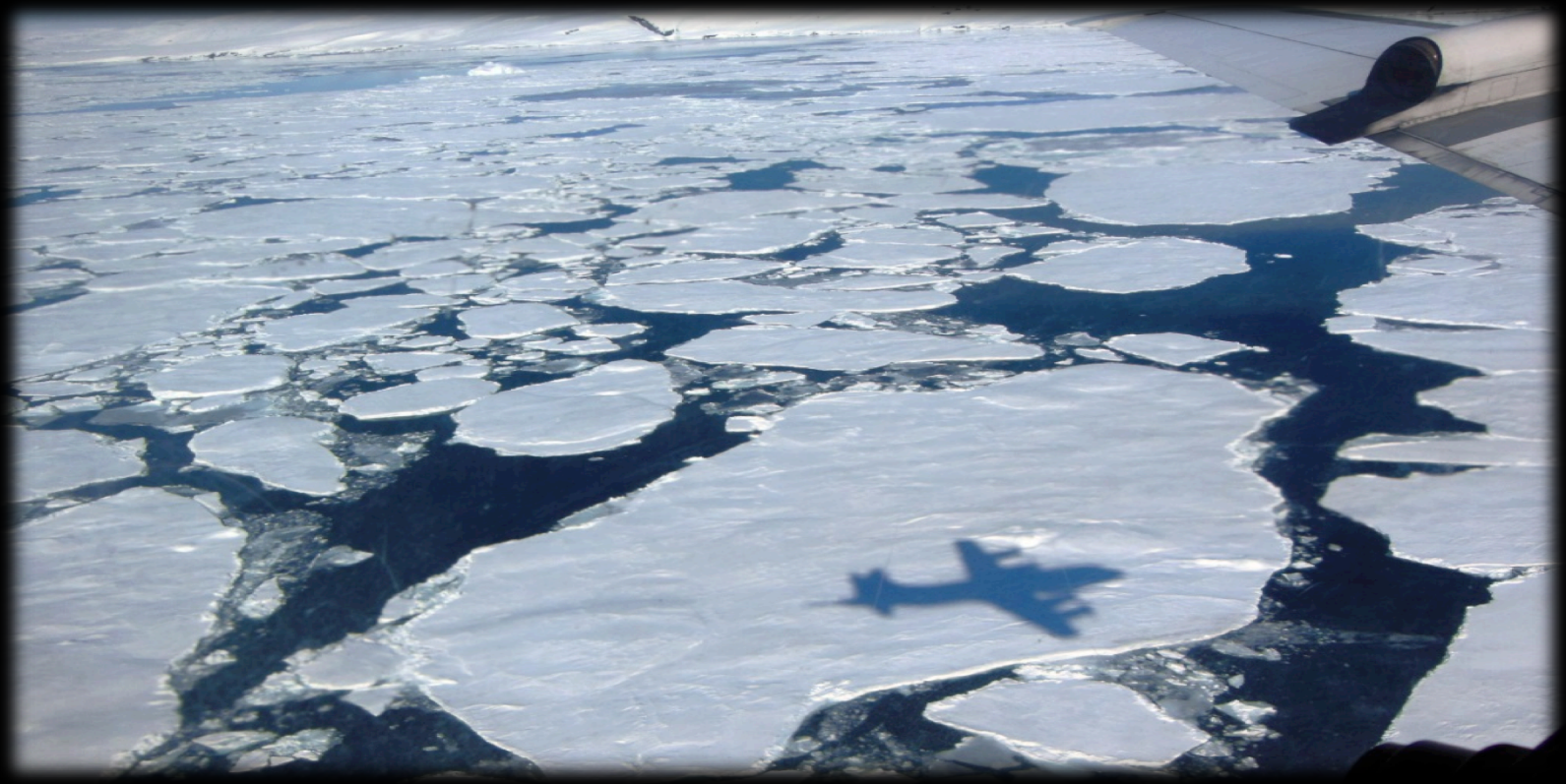
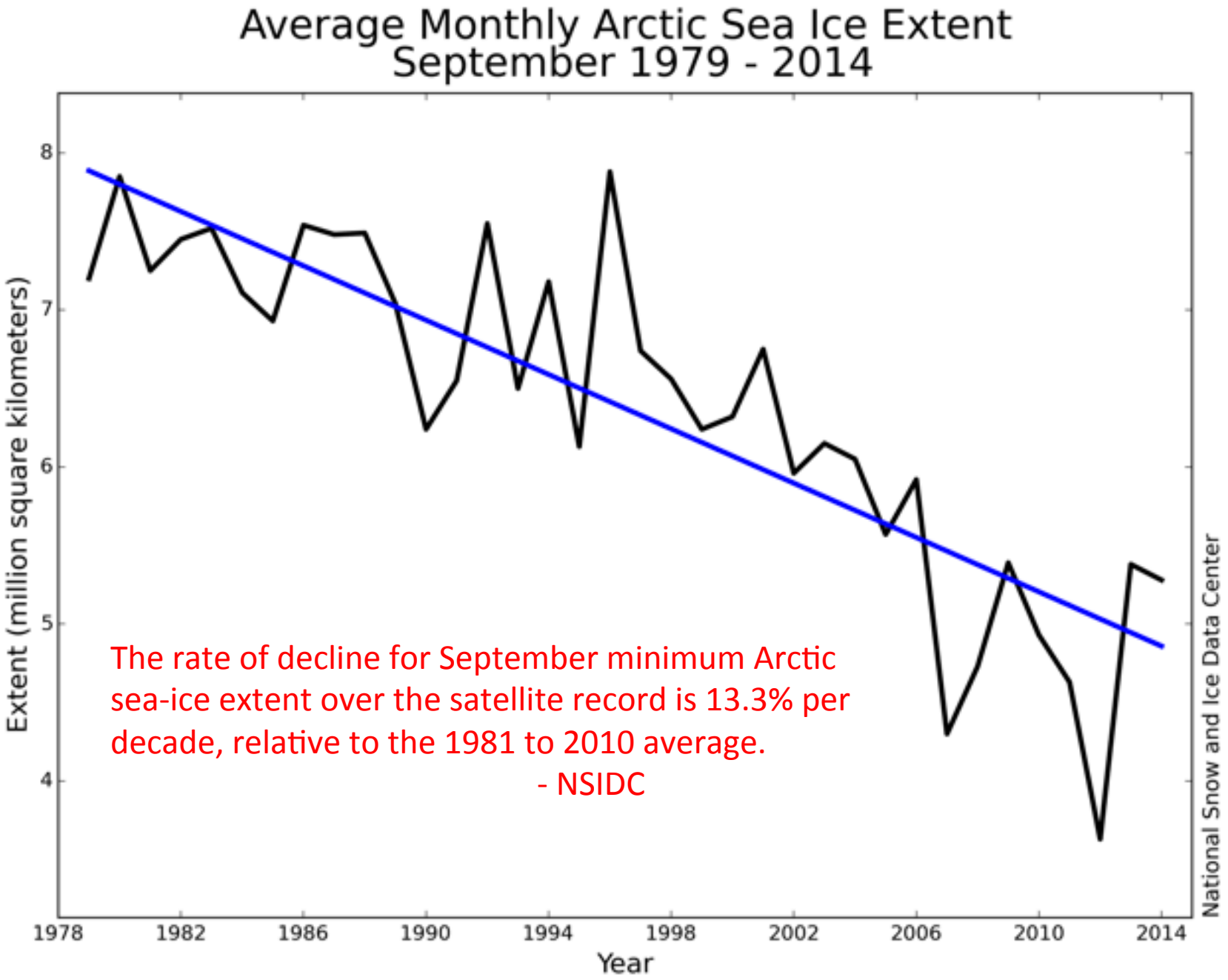
Overview of the Arctic Radiation-IceBridge Sea & Ice Experiment (ARISE)

William L. Smith Jr, NASA LaRC (Project Scientist)
Christy Hansen, NASA GSFC (Project Manager)
and the
ARISE Science Team

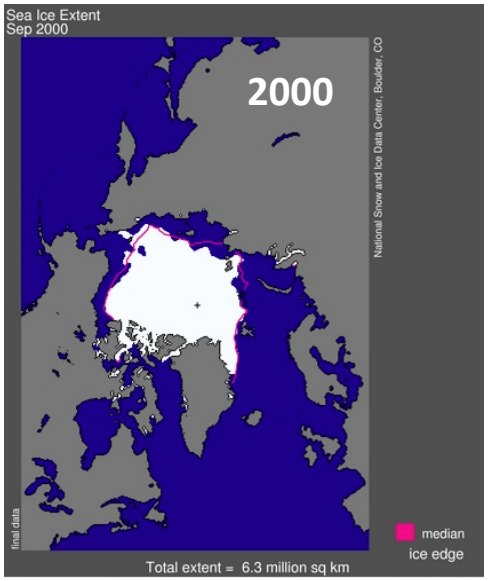


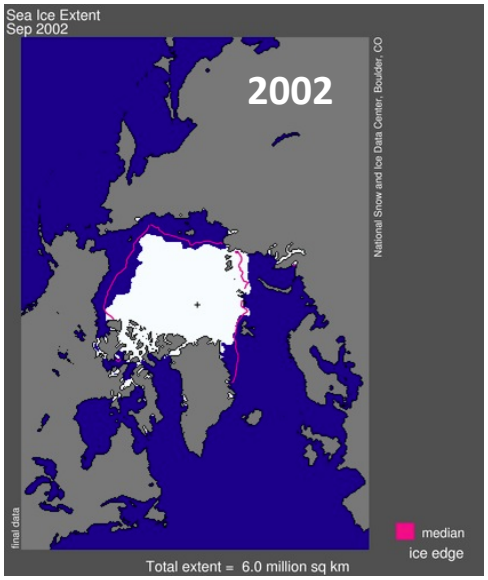
A NASA airborne science experiment to help better understand the relationship between changes in Arctic ice and the regional energy budget as influenced by clouds.

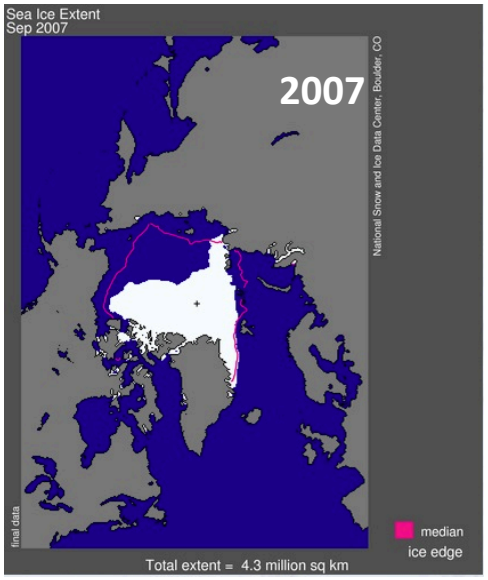

Average Monthly Arctic Sea Ice Extent
September 1979 - 2014
Extent (million square kilometers)
8
7
6
5
4
1978
1982
1986
1990
1994
1998
2002
2006
2010
2014
Year
National Snow and Ice Data Center
The rate of decline for September minimum Arctic sea-ice extent over the satellite record is 13.3% per decade, relative to the 1981 to 2010 average.
- NSIDC

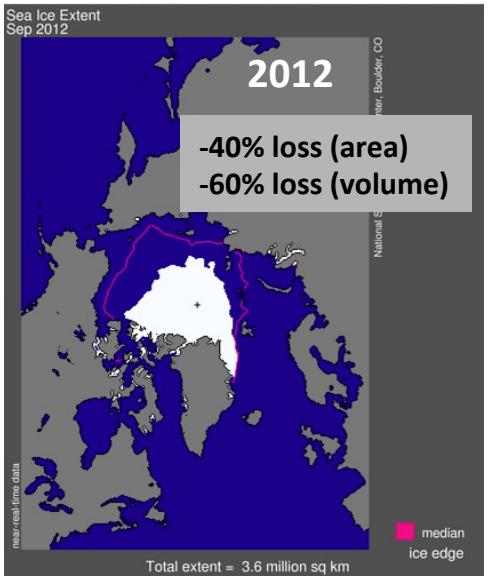
Arctic warming trend ~twice the global average in recent decades.

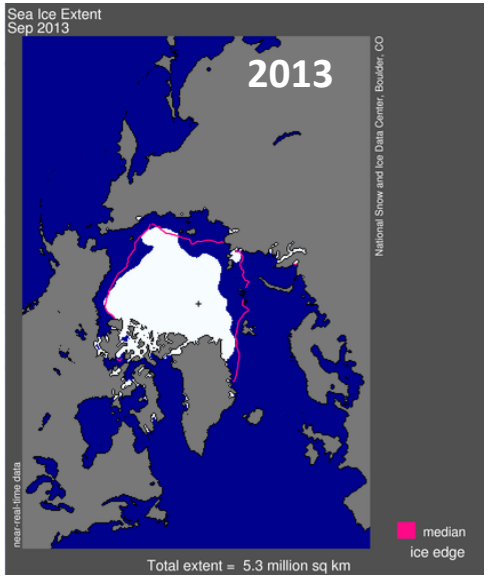
September – Minimum Arctic Sea Ice Extent

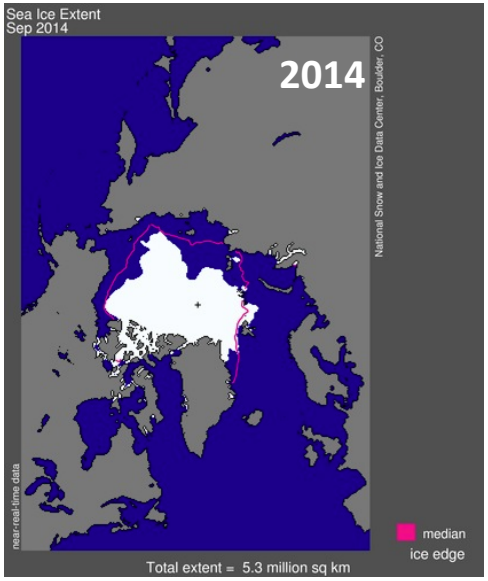




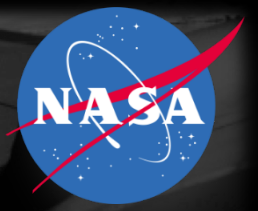








Arctic Climate Change

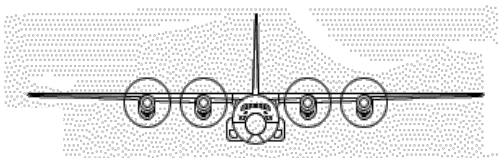


- The rapid decline in Arctic sea-ice is well documented.
- The decline in Arctic sea-ice coverage is highly correlated with how much sunlight is reflected back to space
- Warmer temperatures and less sea-ice cover:
  - Change the TOA and surface energy budgets.
  - Moisten the boundary layer => may change cloud cover
- Changes in Arctic radiation budget can have important implications:
  - Change large-scale atmosphere and ocean circulations =>
  - Change precipitation and temperature patterns =>
  - Influence global sea-level, etc.
- Are Arctic clouds changing? If so, do they offset or enhance the impact of decreasing sea-ice extent on the radiation budget?

NASA satellites are measuring surface and atmospheric conditions, including sea-ice, clouds, and radiation. Need airborne help => ARISE


Aircraft measurements taken during ARISE provide a critical evaluation of satellite measurements and provide information that are difficult to measure or are currently unavailable from satellites.

ARISE Science Objectives



Overall Objective:

Acquire well calibrated datasets using aircraft and surface-based sensors to support the use of NASA satellite and other assets for developing a quantitative process level understanding of the relationship between changes in Arctic ice and regional energy budgets as influenced by clouds.

Specific Objectives:

1. From the NASA C-130, measure spectral and broadband radiative flux profiles, quantify surface characteristics, cloud properties, and other atmospheric state parameters under a variety of Arctic atmospheric and surface conditions (including open water, sea ice, and land ice), and coinciding with satellite overpasses as much as possible.

2. Acquire detailed measurements of land and sea ice characteristics to help fulfill the NASA Operation IceBridge (OIB) mission objectives. OIB is an ongoing airborne science program to characterize annual changes in sea-ice, glaciers and ice sheets, and to bridge gap in NASA IceSat satellite missions.

NASA C-130: An airborne radiometer with in-situ probes and a laser altimeter to characterize the surface, atmosphere and radiative effects

Wing-tip probe for atmospheric temperature, humidity and winds

Broadband SW and IR, spectral SW radiometers for downwelling radiation and cloud properties aloft

Probes to measure cloud properties directly

Broadband SW and IR, spectral SW radiometers for upwelling radiation and cloud properties below

Laser Altimeter to characterize sea and land ice properties

Digital Camera System

NASA C-130 PAYLOAD

Instruments	Measurement	Characteristics	Products
Broadband Radiometers (BBR) **A. Bucholtz, NRL**	SW and LW fluxes (↑, ↓) SW total, direct & diffuse (↓)	SW: modified K&Z CM-22 (0.2-3.6 µm) LW: modified K&Z CG-4 (4.5-45 µm) TDDR: Delta-Devices SPN-1 (0.4-2.7 µm)	Net SW, LW Irradiance, direct/ diffuse SW partitioning, absorption, heating rates Surface albedo, cloud albedo
Spectral Solar Flux Radiometer (SSFR) **S. Schmidt, U. of Colo.**	Spectral SW fluxes (↑, ↓)	370-2170 nm, Resolution: 8-12 nm Leveling platform	Spectral fluxes, albedo Cloud properties
Spectral Sun-photometer 4STAR **J. Redemann, NASA ARC**	Spectral radiancse (↓) Modes: direct beam, sky scanning, zenith	380-1700 nm	aerosols, gases, cloud properties above aircraft
Heitronics KT-19 **D. Van Gilst, NSERC/UND**	IR window radiance (↑, ↓)	9.6-11.5 µm	Skin temperature, sky and cloud temperature
Land, Vegetation, and Ice Sensor (LVIS) **B. Blair, GSFC**	Geo-located waveform vector	1064 nm Scanning: 20 minute footprint, 2 km swath from 10 km Full waveform recorded	Surface elevation, Sea-ice freeboard, Melt-pond distribution Cloud top height

NASA C-130 PAYLOAD

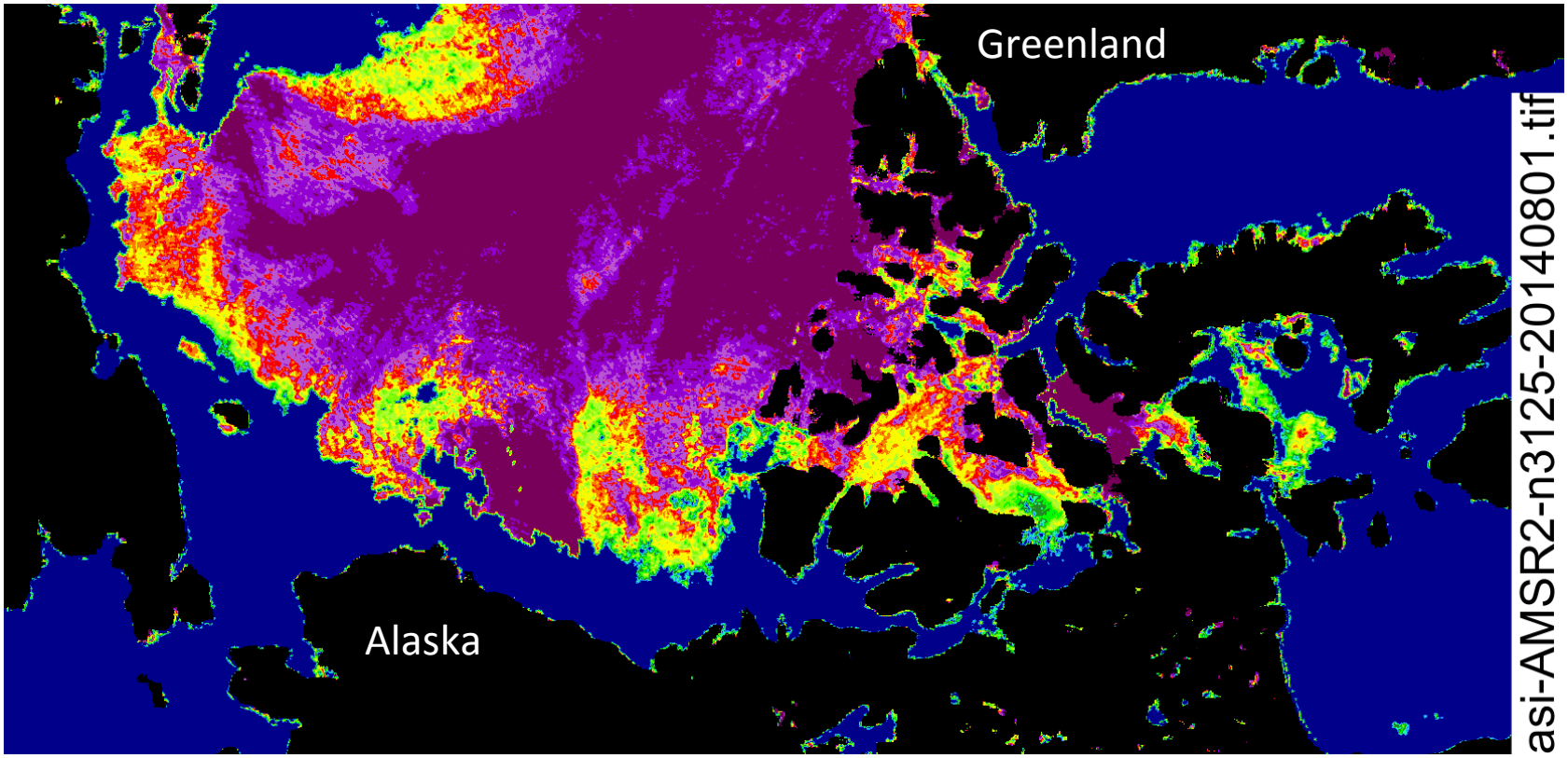
Instruments	Measurement	Characteristics	Products
Cloud Droplet Probe CDP	Cloud droplet size distribution	DMT Inc CDP: 2-50 µm	N(r), LWC
WM-2000 TWC/LWC sensor	Total and Liquid water content	SEA, Inc hot wire probe	TWC/LWC/IWC
Microwave radiometer (MWR)	183 +/- 1, 3, 5 GHZ	ProSensing Inc. G-BAND Vapor radiometer (GVR)	LWP, precipitable water
B. Anderson, NASA LaRC			
Navigation and MET data	Aircraft location, attitude T, q, winds	Basic air data system AIMSS-20 3-stage hygrometer	Aircraft location, attitude T, q, winds
D. Van Gilst, NSERC/UND			

ARISE FLIGHT PROFILES

- Specific flight lines over sea-ice for IceBridge (high altitude surveys with LVIS)
  - fly repeat lines from previous campaigns
- New lines for IceBridge and to support radiation experiments
  - characterize sea-ice across MIZ and repeat during ARISE period
- CERES gridbox experiments
  - map radiative fluxes from C-130 to test CERES gridded TOA and SFC products over wide range of arctic surface conditions
  - acquire other data (clouds, ice, T,q) to test CERES inputs
- Profiles focused on low clouds
  - radiative closure studies
  - test retrievals (from satellite and aircraft radiometers)
- Surface albedo experiments
  - diffuse vs clear sky, test TOA calculations

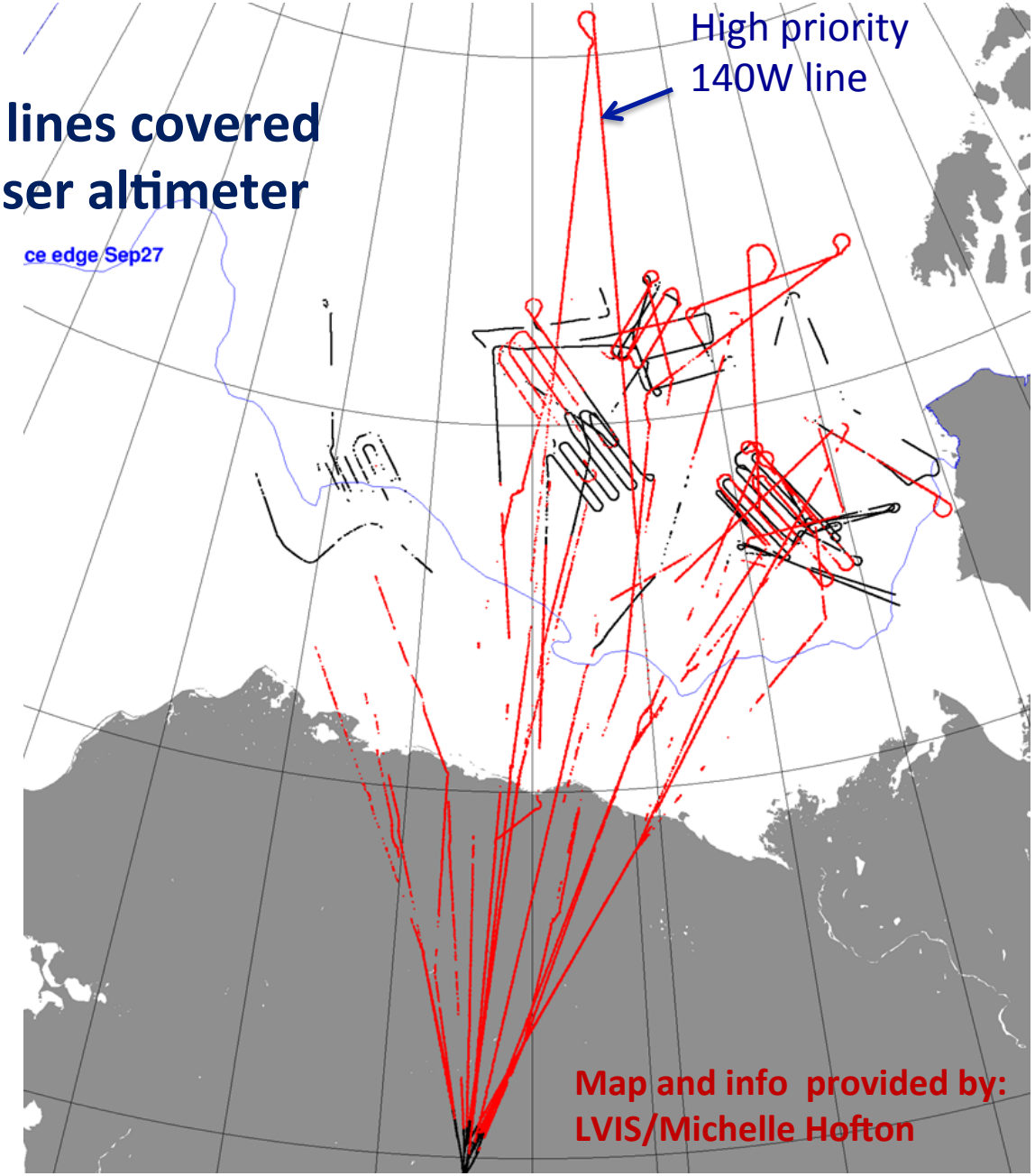
AMSR-2 Sea-ice Concentration
Aug 1 - Sept 30, 2014

U. of Bremen, Spreen et al., 2008 (JGR)



Animation created by Matt Beckley, NASA GSFC

ARISE sea ice lines covered by the LVIS laser altimeter



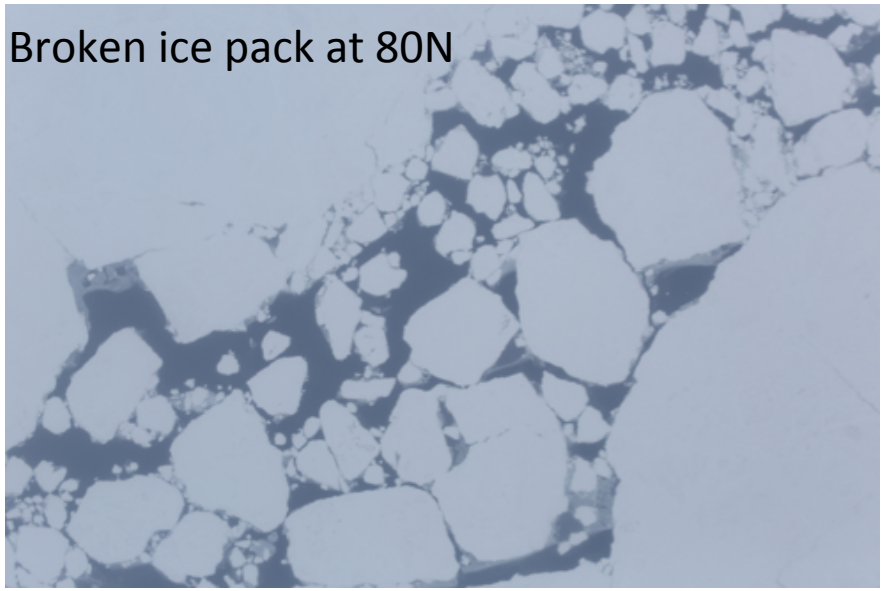
KEY

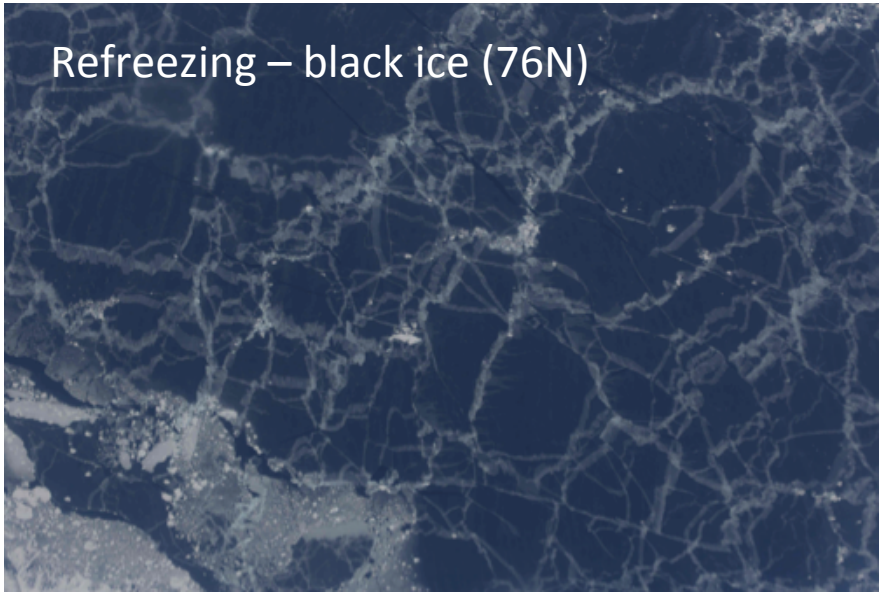
(provided by LVIS: M. Hofton)
** Combined red and black shows locations where LVIS collected surface data.

**The significance of the red areas is that LVIS are actually collecting a swath of data (12degs around nadir - so anywhere up to ~1.7km wide swath of data).

**For the low altitude portions (the black areas), LVIS coverage is a much narrower swath

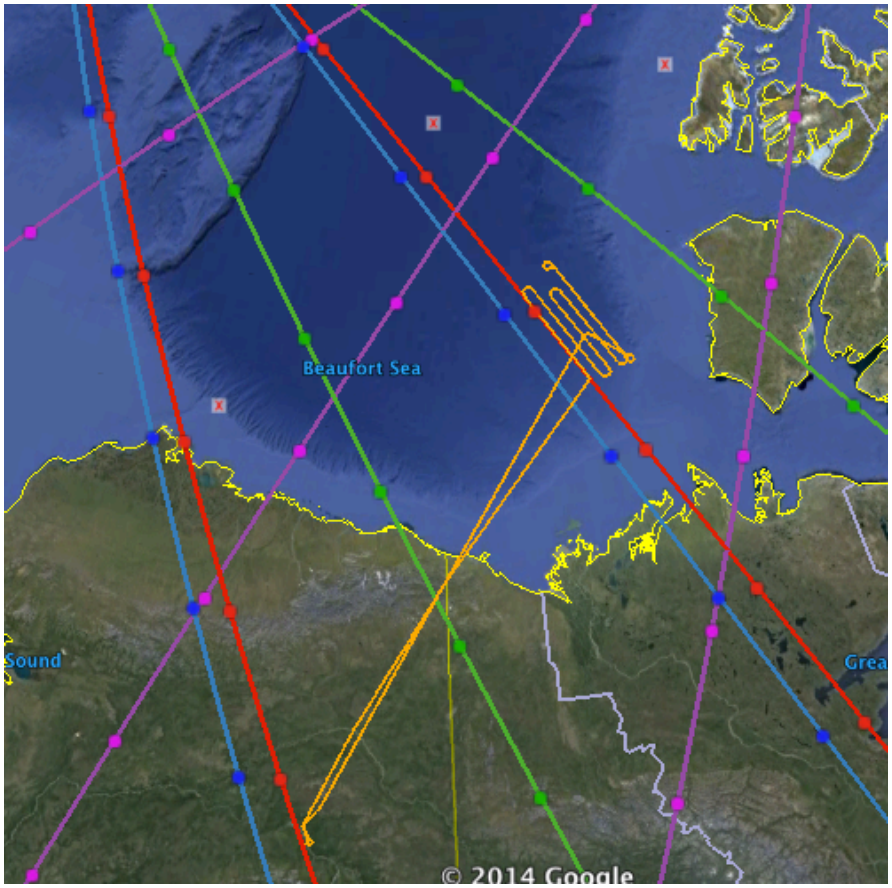
WIDE RANGE OF SEA-ICE CONDITIONS OBSERVED



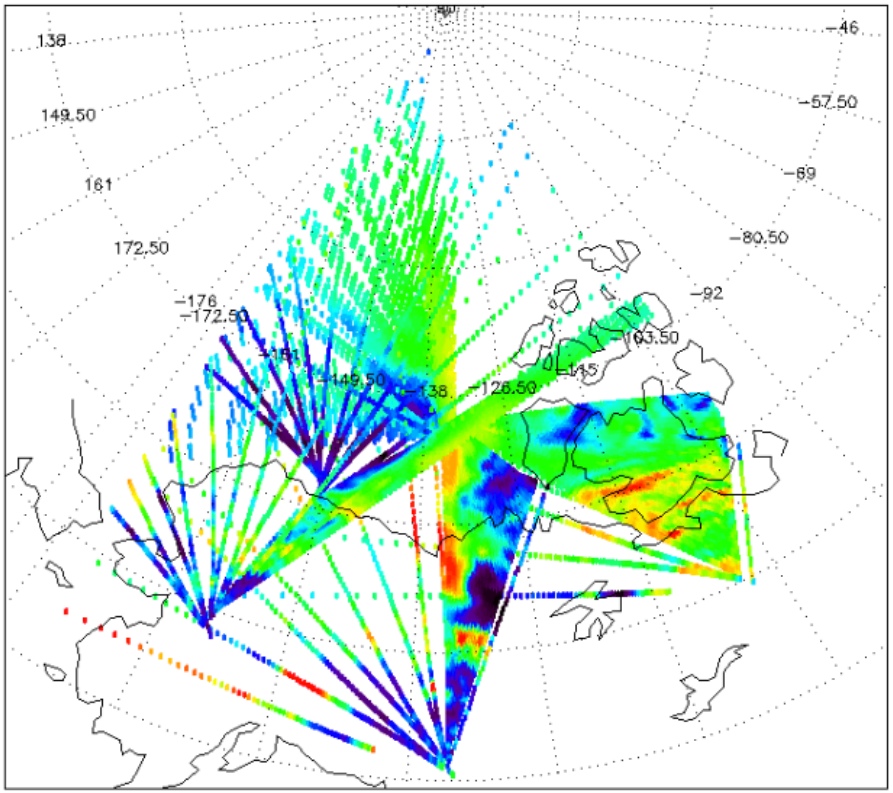


Grid Box Experiments

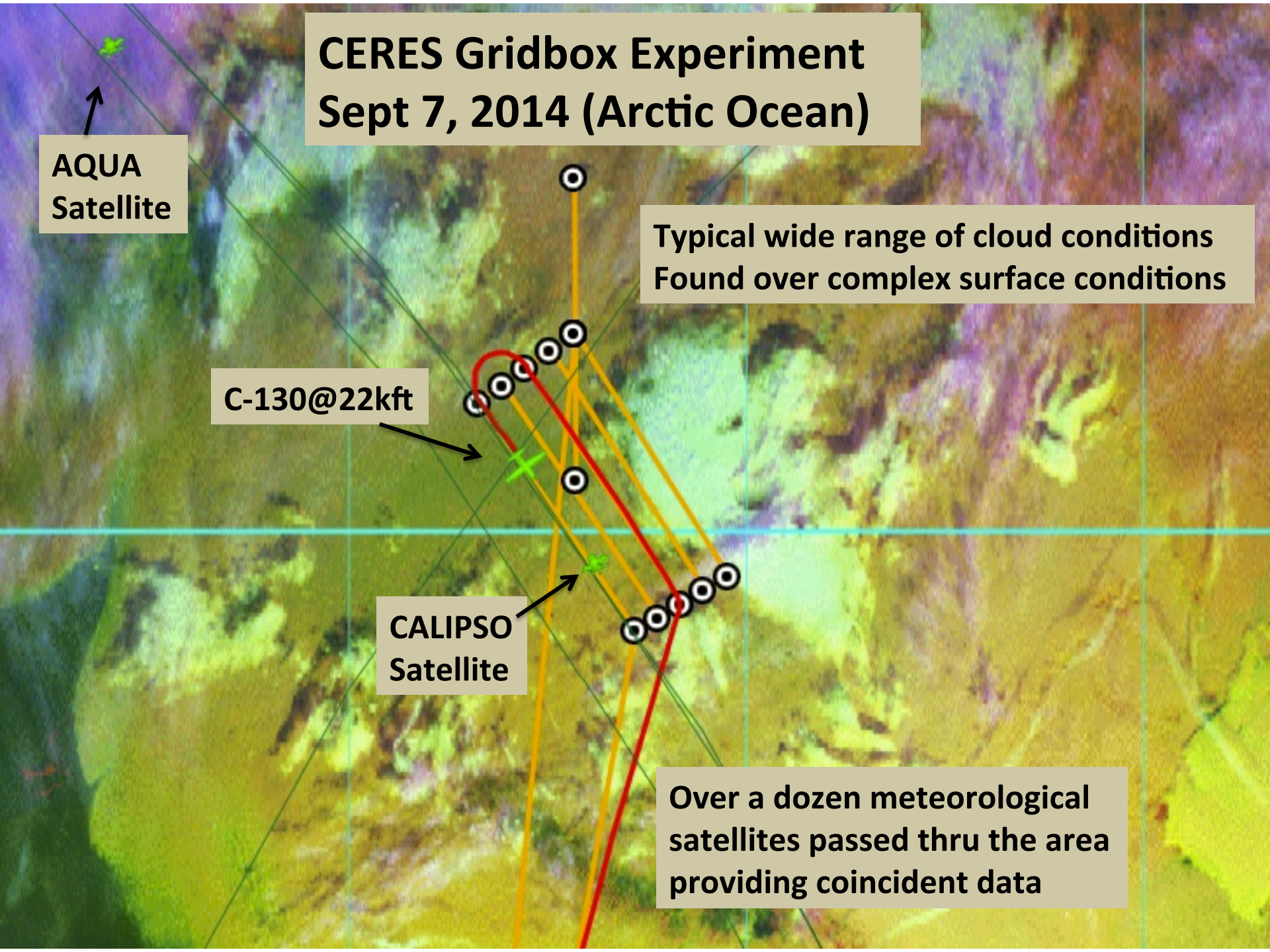
- Focus mapping pattern on TOA or SFC
- 2-3 hours centered near solar noon
- Coincident with lots of CERES overpasses (up to 6!)
- Targets pre-selected to coordinate PAPS from TERRA

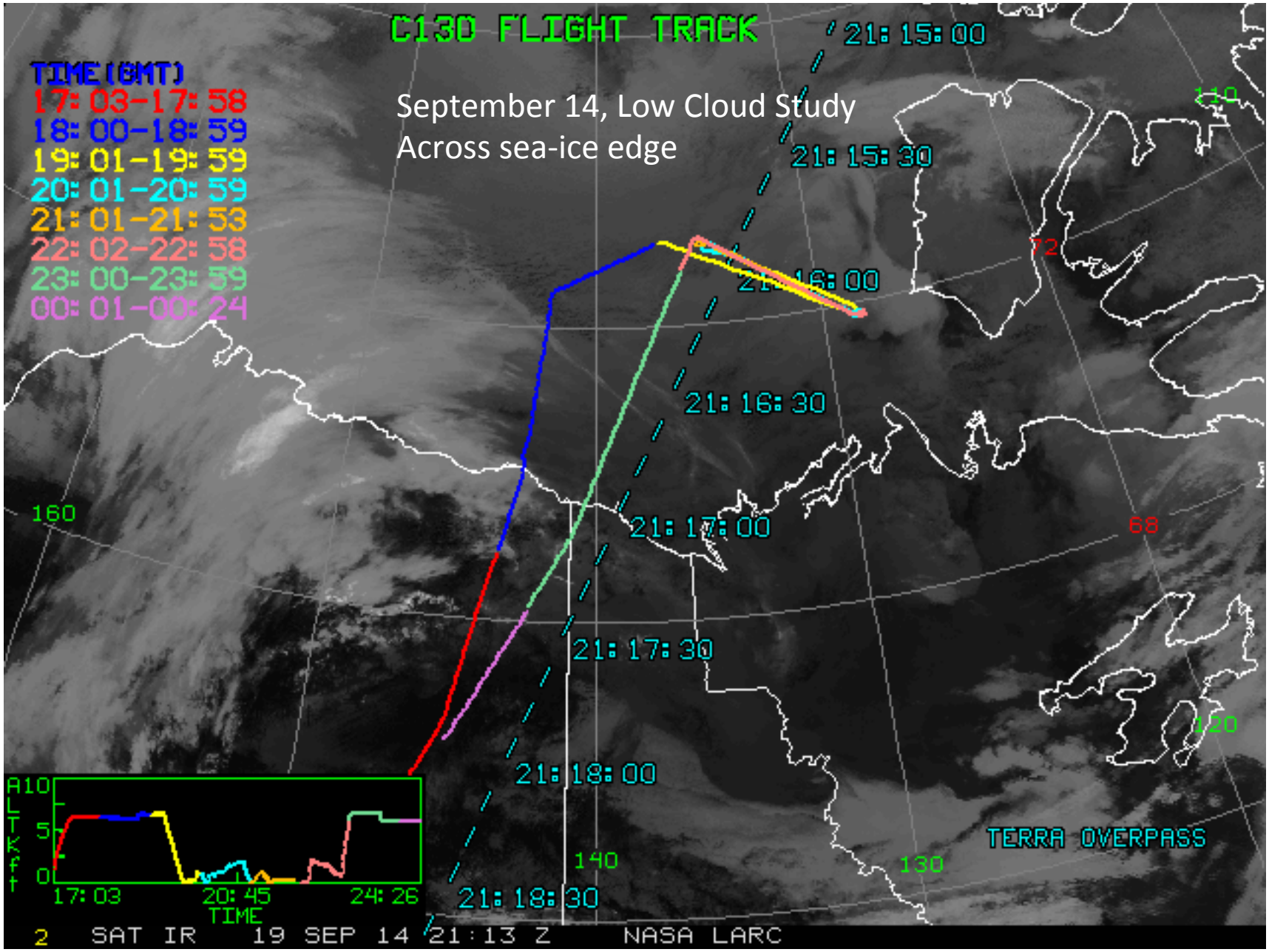


TERRA PAPS thru gridbox to increase sampling



Overpasses: Red CALIPSO/CloudSat, Blue Aqua, Green S-NPP, Purple Terra.


CERES Gridbox Experiment
Sept 7, 2014 (Arctic Ocean)
AQUA
Satellite
Typical wide range of cloud conditions
Found over complex surface conditions
C-130@22kft
CALIPSO
Satellite
Over a dozen meteorological
satellites passed thru the area
providing coincident data


C130 FLIGHT TRACK
TIME(GMT)
17:03-17:58
18:00-18:59
19:01-19:59
20:01-20:59
21:01-21:53
22:02-22:58
23:00-23:59
00:01-00:24
September 14, Low Cloud Study
Across sea-ice edge
21:15:00
21:15:30
21:16:00
21:16:30
21:17:00
21:17:30
21:18:00
21:18:30
110
72
160
68
120
140
130
TERRA OVERPASS
A10
LTKft
5
0
17:03
20:45
24:26
TIME
2 SAT IR 19 SEP 14 21:13 Z NASA LARC

Radiation Sandwich/Wall Pattern

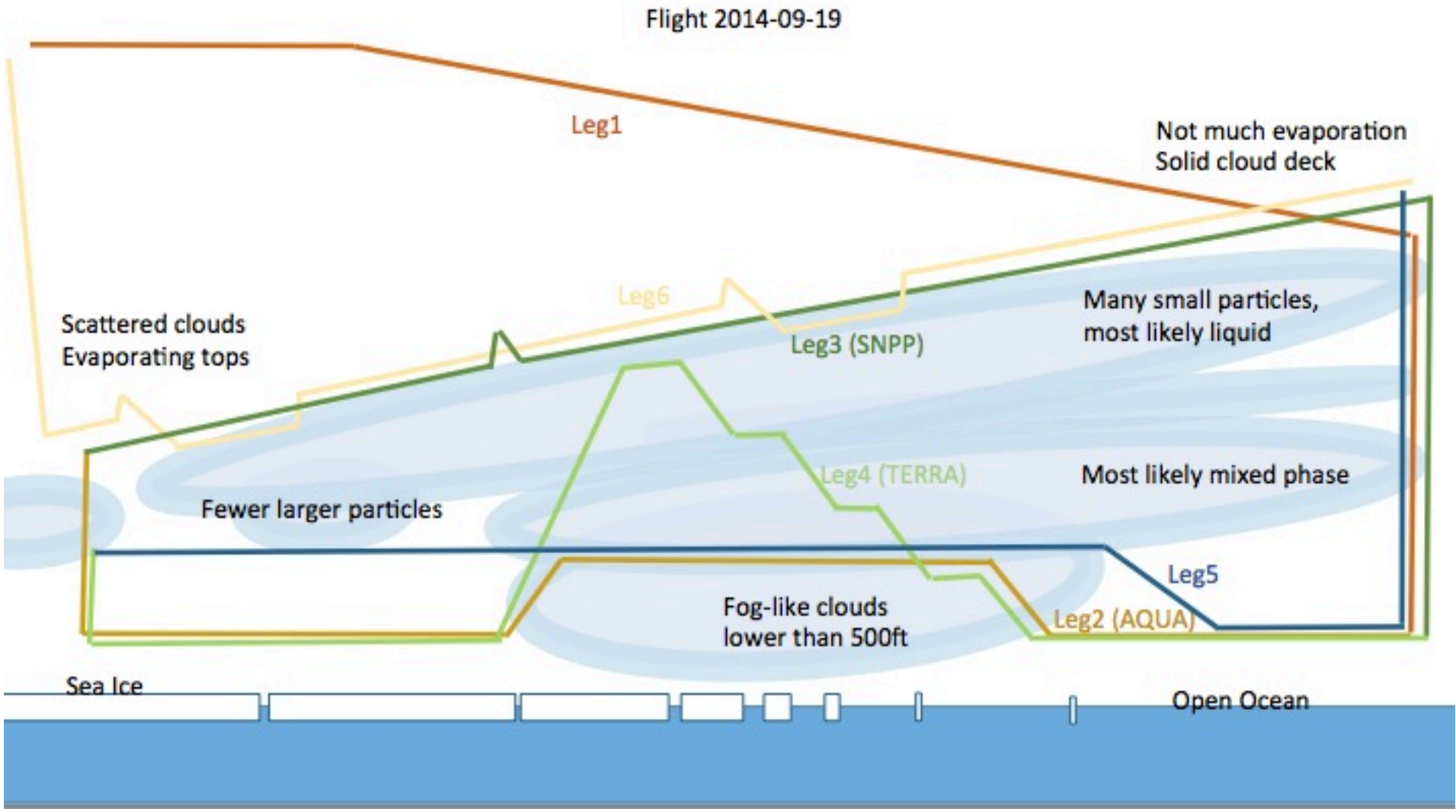
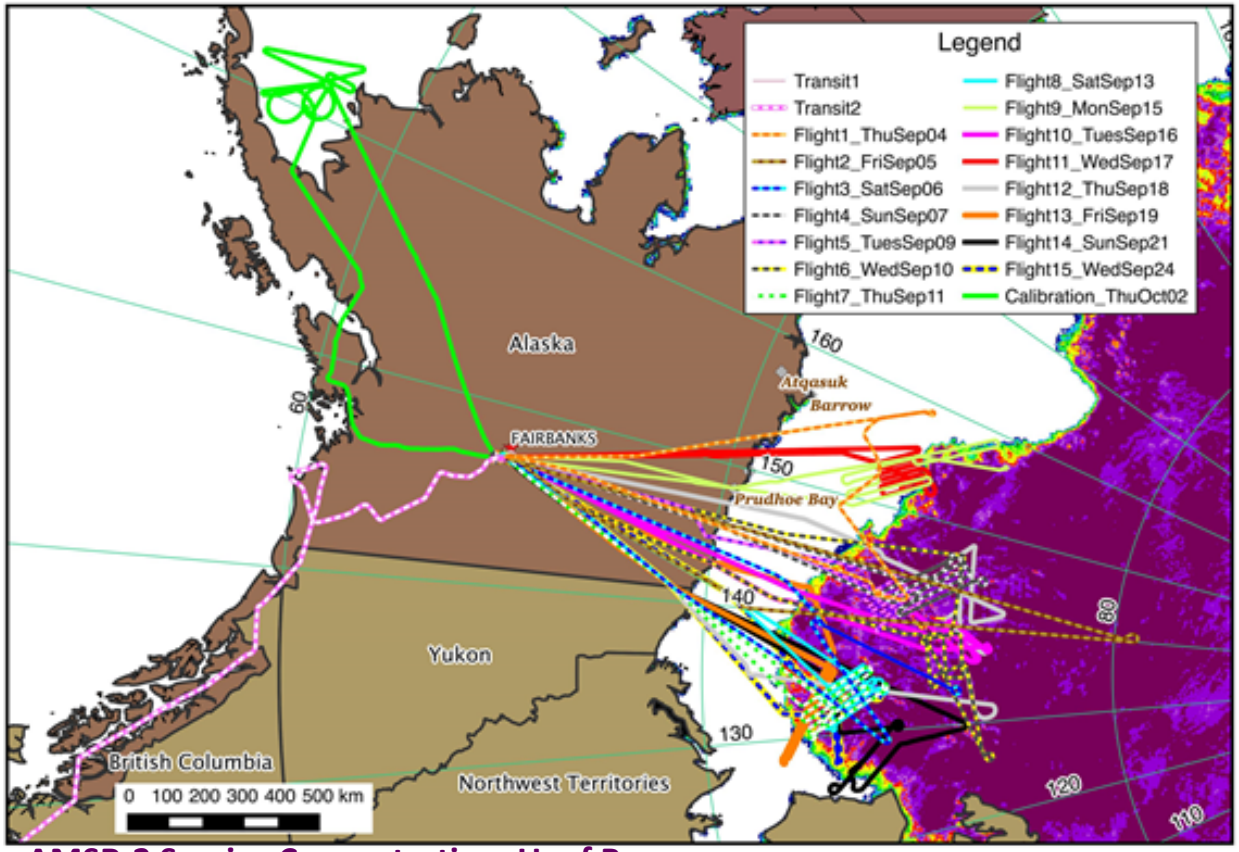


Illustration by Sam LeBlanc, NASA ARC

ARISE MISSION SUMMARY – 10/5/14

Flight Map Summary: shows 17 ARISE science flights completed



AMSR-2 Sea-ice Concentration, U. of Bremen
Spreen et al., JGR (2008)

Map created by LVIS/Matt Beckley

ARISE Science Reports:
https://espo.nasa.gov/missions/arise/mission-flight-docs

"Days" Breakdown

- ✓ 35 days in field
- ✓ 3 transit flts complete
- ✓ **17 sci flts complete**
- ✓ 1 planned maint.
- ✓ 6 reqd hard down days
- ✓ 1.5 wx. days
- ✓ 7 unplanned maint. no-fly days

Flight Hours

- ✓ 159 used
- ✓ 70 hours left

Asset Coordination

- ✓ TERRA
- ✓ AQUA
- ✓ CALIPSO
- ✓ CLOUDSAT
- ✓ METOP-A,B
- ✓ SUOMI NPP
- ✓ NOAA 15,18,19
- ✓ CryoSat-ESA
- ✓ Mable
- ✓ SIZRS 140/150

Mission Highlights

ARISE Science Reports:
https://espo.nasa.gov/missions/arise/mission-flight-docs

- 17 Science flight conducted (150 hours)
- 6 grid box experiments for CERES
- Numerous sea-ice lines and Alaskan glaciers characterized for IceBridge
- Observed the sea-ice transition (melting early, then refreezing) and characterized a wide range of sea-ice conditions and associated cloud properties and radiative effects
- Low clouds were geometrically and optically thin, often multi-layered with fog at the surface at times
- Conducted numerous focused low cloud radiative closure experiments
- Observed lots of haze
- Conducted first ever underflight of Cryosat-2 with LVIS
- Conducted calibration flight for radiometers including Langley for 4STAR, maneuvers to characterize airframe effects and to calibrate the MET data system

Education & Outreach

News Releases

1. 8/14 – **NASA to Investigate Climate Impacts of Arctic Sea Ice Loss**
   http://www.nasa.gov/press/2014/august/nasa-to-investigate-climate-impacts-of-arctic-sea-ice-loss/
2. 9/16 – **NASA Airborne Campaigns Focus on Climate Impacts in the Arctic**
   http://www.nasa.gov/press/2014/september/nasa-airborne-campaigns-focus-on-climate-impacts-in-the-arctic/

News Conference – Media Day

1. 9/16 – Media teleconference on NASA campaigns in Alaska. Participants: Bill Smith (ARISE), Chip Miller (CARVE), Evan Burgess (OIB-Alaska), Tom Wagner (NASA HQ)
2. Local media on-site conducted interviews, took photos and video

Mission Updates

http://www.nasa.gov/mission_pages/icebridge/news/arise14/index.html

1. 9/18 – **First Four Flights for ARISE**
2. 9/17 – **ARISE Flies High and Low**
3. 9/24 – ARISE Continues Cloud and Ice Studies

Video

8/14 – **Arctic Mission Takes Shape**
http://youtu.be/GNwkQsmTXfg

Blog Posts

1. 9/2 – **Preparing for the Trip North -**
   http://earthobservatory.nasa.gov/blogs/fromthefield/2014/09/02/preparing-for-the-trip-north/
2. 9/8 – **May the 4STAR Be With You**
   http://earthobservatory.nasa.gov/blogs/fromthefield/2014/09/08/may-the-4star-be-with-you/
3. 9/17 - **Flying With ARISE**
   http://earthobservatory.nasa.gov/blogs/fromthefield/2014/09/17/flying-with-arise/
4. 9/18 – **Bringing It All Together: Planning ARISE**
   http://earthobservatory.nasa.gov/blogs/fromthefield/2014/09/18/bringing-it-all-together-planning-arise/
5. 9/22 – **Digital cameras blog post http://www.nasa.gov/mission_pages/icebridge/news/arise14/index.html**

Earth Science Data and Information System Project, Code 423

423-xx-xx

Arctic Radiation-IceBridge Sea & Ice Experiment (ARISE) Data Management Plan

https://espo.nasa.gov/missions/arise/science

October 2014

DATA AVAILABLE APRIL 2015:

https://www-air.larc.nasa.gov/cgi-bin/ArcView/arise

National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

QUESTIONS ?